Global Methane Initiative

Ethiopia Solid Waste & Landfill

[Country Profile and Action Plan]

Community Development Research
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I. INTRODUCTION

Globally, different initiatives are being made to control greenhouse gas (GHG) emission from various sources; Global Methane Initiative (GMI) is one of them. Global Methane Initiative is a multilateral partnership, the purpose of which is to create a voluntary, non-binding framework for international cooperation to reduce anthropogenic methane emissions and advance the recovery and use of methane as a valuable clean energy source. Other benefits include increasing energy security, enhancing economic growth, improving air quality, and improving industrial safety. The Initiative is implemented in collaboration among developed countries, developing countries, and transitional economics—in coordination with the private sector, researchers, development banks, and other relevant governmental and non-governmental organizations.

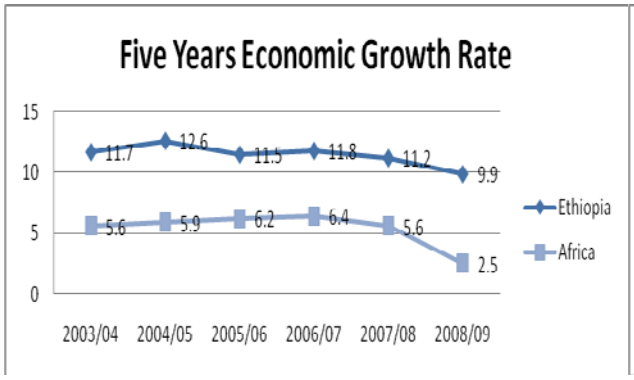
GMI focuses on the development of strategies and markets for the abatement, recovery, and use of methane through technology development, demonstration, deployment, and diffusion; implementation of effective policy frameworks; identification of ways and means to support investment; and removal of barriers to collaborative project development and implementation. GMI targets five major methane sources: agriculture, coal mines, landfills, oil and natural gas systems, and wastewater. This country study is primarily focused on major solid waste and landfill management practices in Ethiopia. The main objectives of this assessment are:

- To assess the overall characteristics and methane emissions potential in various municipalities in Ethiopia.
- To examine the managerial and technical capacity of the respective municipalities with respect to landfill management and development and implementation of landfill gas- energy or compost.
- Layout an action plan which integrated with other local and international initiatives.

About Ethiopia

Ethiopia is located in the northeast of Africa and it is one of the largest and most populous countries of the continent. It makes up most of what is known as the horn of Africa, and it is bordered by Djibouti and Eritrea on the north, Somalia on the east, Kenya on the south, and Sudan and South Sudan on the west. The country's diverse landscape encompasses lowlands, deserts, canyons and high plateaus. Its climate varies from very dry to very wet.

Ethiopia has shown tremendous economic growth in the last several years. The country's GDP growth rate had been around 10% between 2006 and 2010. The service and industry sectors in the urban areas have been major drivers of this growth. The urban areas have contributed about 60% of the GDP growth in the last few years and the service and industry sectors are now the major part of Ethiopia's GDP with about 53%. With the rise in urbanization and as well as growth in service and industry sector, the role of urban areas in becoming a major economic engines will increase. With it also comes an increase in responsibilities of municipalities to provide effective and efficient services to residents.



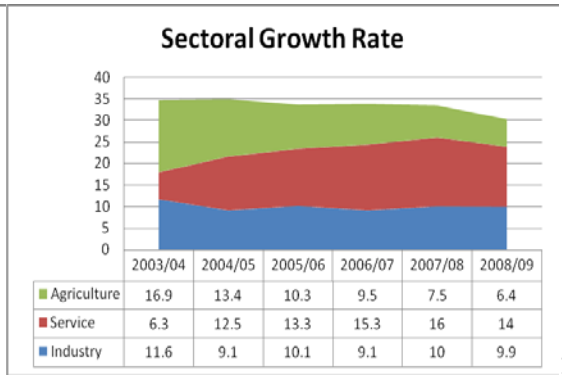


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Figure 1: Five years econonomic growth rate: Ethiopia and Africa
Figure 2: Sectoral growth rate in Ethiopia

Even though Ethiopia is largely a rural country, with 85% of the total population living in rural area, the country has a relatively high urbanization rate. In total 8.2 million people live in urban areas. This is 15% of the total population of Ethiopia. The average growth of the urban population is one of the highest in Africa and it is estimated to be around 15%. Addis Ababa is one of the fastest growing cities in Africa and the city is currently suffering from the problems that go with rapid population growth and urbanization: a shortage of decent housing and a lack of basic infrastructure and public facilities such as water, electricity and sewerage. Also, the capacity of the local government to manage the city is inadequate and crime, the number of street children and homeless persons, traffic congestion and poverty are increasing. The urban "explosion" of Addis Abeba is not difficult to understand. A high birth rate surplus and important migration from rural areas and secondary cities to the capital are all important aspects of an explanation for this urban explosion.

Scenes from the town of Nazret,Oromia. One of the fastest growing towns in Ethiopia, and Addis Ababa

1 African Development Bank, Economic Brief, Vol. 1 Issue 5, 17 Sept. 2010

II. SUMMARY OF THE SOLID WASTE MANAGEMENT SECTOR

Urban waste management has been a challenge for municipalities and urban governments in the developing world, largely due to poor infrastructure, bureaucratic competence and limited institutional capacity of the municipalities. Municipalities throughout Ethiopia are not free of these problems are they facing a major challenges with solid waste collection and landfill management. Addis Ababa, as the largest city in the country, as well as other smaller cities has been grappled with an increasingly growing urban waste management problem.

According to Environmental Protection Authority and World Bank study conducted in 2004, per capita amount of waste generated in Ethiopia ranged from 0.17 to 0.48 kg/person/day for urban areas to about 0.11 to 0.35 kg/capita/ day for rural areas. The range depends on several factors such as income and season. The total generation of municipal solid waste in Ethiopia in 2003 is estimated to be 2.8 to 8.8 million tones. This can be split to approximately 0.6 to 1.8 million tons from urban areas and 2.2 to 7 million tons from rural areas (EPA/World Bank, 2004).

In many of the cities in Ethiopia the municipality administration is responsible for waste collection. Though, there is a wide variation in performance in relation to waste collection in cities of Ethiopia, it has become a common business practice to have household waste to be pre-collected by individuals who are organized through formal or informal association. The pre-collected waste is then transferred into containers which are then collected by municipalities. Nevertheless, in many cities there are not enough containers to cover the population and vehicles are typically under maintenance or out of service for long periods of time. As there is very limited effort to recycle, reuse or recover the waste that is being generated; waste disposal has been the major mode of waste management practice. When considering solid waste management in general, it should be noted that it is rather small fraction of waste that

ever reaches dump sites or landfills in Ethiopia. Some studies have shown that only 43% of waste is collected in the country are properly collected and disposed in open landfills. The remaining waste is indiscriminately disposed off in drainage lines, open spaces, street sides or is informally burned. The collection efficiency varies among the cities, Mekelle being one of the best examples, has a collection rate of 82% and Jimma, which is one of the worst, has a collection rate of 30%.

This assessment covers an in-depth analysis waste collection and landfill use of for three municipalities: Addis Ababa, Mekele and Dire Dawa.

2.1 Addis Ababa City Administration

Addis Ababa is the capital city of Ethiopia and the seat for different international organizations such as UN Economic Commission of Africa and Africa Union. The total area of the city is 504km^2 with an average altitude of 2408m above sea level. The city lies between 09^0 02' Latitude and 38^0 44' Longitude. Based on Ethiopian Central Statistics Agency 2008 report, the city has an estimated population of 2,914,405 with 3% annual growth rate. Other data shows the city has a population of over four million. The city receives a mean precipitation rate 1188.27 mm per annum and the annual mean maximum and minimum temperature of the city for the year 2007 were 23.8^{0}C and 10.2 ^{0}C respectively.

The current daily waste production of Addis Ababa is estimated to be 2,297 m^3 or 765 tones. The waste production rate per person is about 0.45 kg/day. However, there is seasonal variation in the per capita solid waste generation. From the daily solid waste generated in Addis Ababa, 65% is collected, 5% recycled and 5% composted. The remaining 25% is simply dumped on open sites, drainage channels, rivers and valleys as well as on the streets. 70% of the waste generated comes from households, 9% from commercial areas and 6% street sweeping, 5% from industrial waste and the remaining from hotels, hospitals

etc. The estimated physical composition is as follows: vegetables 4.2%, paper 2.5%, rubber/plastics 2.9%, wood 2.3%, bone 1.1%, textiles 2.4%, metals 0.9%, glass 0.5%, combustibles leaves 15.1%, non-combustible stones 2.5% and all fines 65%.

Table 2. Source of Solid Waste in Addis Ababa

Source of Solid Waste	**Percent (%)**
Domestic House Holds	70.0
Commercial/Retail	9.0
Street Sweeping (Soil & Refuse)	6.0%
Industrial Manufacturing	5.0%
Hotels	3.0%
Hospitals	1.0%

TABLE 3. Physical Composition of Solid Waste in Addis Ababa

Constituent	**Percent (%)**
Vegetables	1.93
Paper	2.90
Rubber	0.19
Leather	0.41
Wood	2.89
Plastic	1.58
Bone	2.11
Textile	1.39
Ferrous metals	0.69
Aluminium	0.0
Glass	0.79
Combustible(Leaves, Grass, etc)	26.26
Non-Combustible(Sand, Grit, Soil, etc)	26.26
Soil/Fines <10 mm	30.82
Fines<55 but >10 mm	25.87
Total	100%

Table 4. Solid Waste Generation Rate in Addis Ababa

Income Group	**Data**	
1. High Income (<600 Birr/month)	Gram/capita/day	477
	m^3/capita/day	0.002226
	Density (ρ), Kg/m^3	220
2. Middle Income (300-600 Birr/month)	Gram/capita/day	236
	m^3/capita/day	.001246
	Density (ρ), Kg/m^3	196
3. Low Income (<300 Birr/month)	Gram/capita/day	260
	m^3/capita/day	.001316
	Density (ρ), Kg/m^3	206
General Population	Gram/capita/day	252
	m^3/capita/day	.00122
	Density (ρ), Kg/m^3	205

For planning purposes, the Addis Ababa municipality uses an average house hold solid waste per capita per day solid waste generation rate of 0.45 liters/(person-day), or , 0.15 Kg/(person-day), with an average density of 350 Kg/m^3. This is very small compared to about the per capita waste generation rate of 2.1 Kg/person-day in the USA or other developed nations.

Solid Waste Collection in Addis Ababa

Solid waste collection in Addis Ababa is divided in to two sub-systems - primary and secondary collection.

Primary Collection

Primary collection is done by micro and small enterprises. These enterprises have formal agreement with sub-city administrations to collect waste from households or business establishments and dump them in designated containers. There are about 750 micro and small enterprises organized to pre-collect waste from household. The majority operates in the middle

and high-income residential houses. They collect solid waste using a door-to-door method. The associations' direct links to the waste management apparatus are the woreda which are subset of sub-city. This chain is reflected both in the collection of waste as well as payment mechanism. Once the waste is pre-collected by the individuals, it is dumped in containers which are picked by the sub-city which then dumped at the City's landfill. The payment collection system follows a reverse cycle. Until recently fee collections used to be done by the city which is now transferred to woreda administrations. The woreda offices also make the payment to the associations or individual waste pre-collectors.

Waste pre-collectors in Addis Ababa

Secondary Collection

Secondary Collection is a system whereby solid wastes are transported from containers to the final dumping site. This is usually undertaken by the municipality which represents the highest level in transportation system. The role of the private sector on transportation of solid waste in this system is limited. Currently in the city collects 85% of the waste from containers and dump it in the one open dumpsite known as ''Rappi'' or ''Koshe'' where it disposed all solid waste. The land was established 47 years ago. It is found in the South Western part of the city, located 13 km away from the city center. The present method of disposal is crude open dumping: hauling the wastes by truck, spreading and leveling by bulldozer and compacting by compactor or bulldozer.

Waste containers in Addis Ababa

Addis Ababa City Administration and Solid Waste Collection

The city has gone through administrative redistricting in the past five years and it is currently divided into ten sub- cities. Each sub-city has several woredas (sub-city level administrations) under it. The decentralization system that the federal government has implemented has given more authority to the woreda administrations and the woreda offices have more tasks such as collection taxes and giving business license. The solid waste management system is also currently partially control by the woreda offices. The informal waste pickers who are organized have contractual agreement with the woreda office and each woreda office has one to three cleansing officers who manage the associations. While such arrangement has made service delivery connect better to clients and accessible, it has also been faced with several challenges.

Some of the main challenges the city administration currently faces in solid waste collection and landfill management are:

1. Poor infrastructure of Addis Ababa which makes most part of the city inaccessible;

2. Lack of properly designed collection route system and time schedule;

3. Lack of proper collection of containers and lack of emptying containers when full;

4. Lack of proper truck maintenance.;

5. Poor condition of the final dumpsite as well as lack of promotion on waste reduction, recycling and composting.

Current solid waste collection rate from containers in Addis Ababa is low. Based on planned number of trips and actual trips conducted for the Ethiopian calendar year of 2003 (2009 - 2010), the Addis Ababa Municipality achieved 58% of its target. Performance rate varies among sub-cities. The main challenge for poor pick up rate is associated with frequent breakdown of pickup trucks.

Table 5. Number of trips by municipality trucks in 2003 (Ethiopian Calendar)

S.N	Sub city	Trip Plan	No of trip	Comparative
1	Nefa selk	**19440**	**16572**	**85.25%**
2	Bole	**20160**	**14146**	**70.17%**
3	Akaki	**12600**	**8226**	**69.25%**
4	Kirkos	**21600**	**13018**	**60.27%**
5	Yeka	**20160**	**11362**	**56.36%**
6	Addis ketema	**28800**	**15987**	**55.51%**
7	Gulely	**16200**	**8892**	**54.59%**
8	Ldeta	**20160**	**10983**	**54.48%**
9	Kolfy	**28800**	**13526**	**46.97%**
10	Arada	**25200**	**10149**	**40.27%**
		213120	**123361**	**57.88%**

2.2 Mekele City Administration

Mekele is the capital city of Tigray Region, which is located in the Northern part of Ethiopia. Based on Ethiopian census report the city has an estimated population of 232,119 with 2.5%

growth rate (CSA, 2008). Currently the city has 0.252 kg/day per capita waste generation rate and the city is estimated to generate about 59 tonnes solid waste per day. The wastes that get collected from various streams are sorted at the transfer stations and then dumped into the landfill site. Of the generated waste about 76-83% is composed of organic materials and the other wastes accounted for 17-24%. Of the daily generated waste about 82% is being collected and transported to Mekele landfill site. The remaining wastes is dumped in open spaces, ditches etc.

2.3 Dire Dawa City Administration

Dire Dawa city was established in 1902 as a result of the Ethio-Djibouti railway line, which was built between 1897 and 1917. The city is located in eastern part of Ethiopia and lies between 090 45' Latitude and 410 52' Longitude. Based on CSA report (2008), the urban population of Dire Dawa City Administration is estimated to be 232,854 with 2.5% annual growth rate. The City Administration covers a total area of 1332.62km^2 and has an altitude of 1160m above sea level. The city receives a mean precipitation rate 676.3 mm per annum and the annual mean maximum and minimum temperature of the city for the year 2007 were 32.7 and 18.7 ^{0}C respectively (CSA, 2008).

The per capita waste generation rate of the city is 0.3 kg/day[3] and the city generates an estimated quantity of 77 tonnes of solid wastes per day. Of the total waste generated, 76 % is being collected and disposed at Dire Dawa landfill site and the remaining portion is illegally dumped on open spaces, ditches and the like. The wastes are generally collected in garbage bins and transported to the landfill site using side loaders and lift trucks.

2 The data is obtained from an interview made with Process Owner of Tigray National State , SBPDA (July 2011)
3 Based on information obtained from an Expert of Awareness Raising & Training at DDSBPDA

2.4 Technical & Managerial Capacities

The three landfills i.e. Mekele and Dire Dawa Sanitary landfills & Repi dump site were assessed in terms of human resource capacities to manage the waste disposal sites. Based on the assessment the three cities lack the required technical & managerial skills which are required to run the landfills (Table 6).

Low performance of solid waste collection and landfill management is also associated with absence of skilled manpower. Based on a brief assessment of technical and managerial capacity of the three municipalities, the main challenge has been lack of skilled manpower on landfill management and operations including leachate management and methane recovery. Many of the current landfill managers and operators are trained in either civil engineering or mechanical engineering.

Table 6. Technical & Managerial Capacities Related to three Landfills in Ethiopia

No.	Name of Landfill	Number of Staffs	Skilled/Semiskilled Staffs	Unskilled Staff	Remark
1.	Mekele Sanitary Landfill	3	Urban management (M.Sc.) One B.Sc. holder One Diploma holder	4 Guards 304 waste sorters	There is no skilled manpower on landfill management, landfill operation inc. leachate management , methane recovery , etc
2.	Dire Dawa City Administration	12	Environmental Science (B.Sc.) Two assistants /Data registrars	4 Guards 5 laborers	There is no skilled manpower on landfill management, landfill operation inc. leachate management , methane recovery , etc
3.	Addis Ababa City Administration	69	Technical & Vocational Training. Civil engineer		There is no skilled manpower on landfill management, landfill operation inc. leachate management , methane recovery , etc

4 The city Administration out sourced waste sorting practices (at the landfill site) to waste management cooperatives

III. LANDFILL MANAGEMENT AND OVERVIEW OF LFG POTENTIAL FROM EXISTING DISPOSAL SITES

Methane gas liberating from landfill is a serious threat to our environment as its global warming potential is more than 20 times of that of carbon dioxide (CO_2). Methane emission from landfill is estimated to account for 3–19% of the anthropogenic sources in the world (IPCC, 1996). But unfortunately solid waste (SW) management is much neglected and the maintenance of record in this respect is poor, in Ethiopia. The potential of solid waste for CDM especially for methane capturing is recognized in reducing the potential of GHG emissions while utilizing methane gas for power generation. In this regard, it is important to estimate the potential methane emission or generation from the three landfills and disposal sites. IPCC default method (DM)5 is used for the estimation of methane potential from the three disposal sites. The methodology depends on waste category, degradable organic carbon fraction, and methane gas in landfill (IPCC, 1996).

Standardized and modern landfill management system in Ethiopia is in an infantile stage. There are currently no well managed landfill sites and almost all the current sites are non-engineered open dump sites. However, some municipalities, namely Dire Dawa, Awassa and Mekele have managed to construct landfills with limited proper landfill features.

5 Though IPCC has claimed that DM provides reasonable annual estimate of actual emissions and this has been widely used in the situations where detailed data is not available (IPCC, 1996). But it may not provide realistic estimate as it is assumed that all potential methane is released in the year the waste is disposed off.

Repi Dump Site, Addis Ababa

The largest and oldest landfill site in Ethiopia is located in Addis Ababa. The Addis Ababa landfill site ”Repi” landfill site is located in the south-western expansion areas of Addis Ababa in Lafto-Nifas-Silk Kifleketema (Sub-City). In 1960s, the site was considered to fall outside the city''s master plan since it was inhabited by only a few farmers. The municipal administration of Addis Ababa started to use the site in 1964. Even though it has been the only solid waste disposal site for nearly 50 years, there is still no documented information regarding the site’s feasibility, geological and hydrological conditions, lifespan, and possible impacts on the local environment, except few very recent studies.

Repi landfill in Addis Ababa and residential community behind the landfill

The Repi dump site which has an area of 36.4 hectare located at 13 km from the city center in south western direction. The disposal site has been in operation since 1964 and receives over 750 tons of waste per day. The landfill employs an area method where the delivered waste is placed on flat land. It does not involve excavation of trenches; instead, a layer of waste is spread and compacted on the surface of the ground. The wastes deposited at the landfill are predominately solid wastes from both industrial and domestic sources. The landfill does not have a fence structure no fence that protects the entrance of animals such as sheep, goats, cats and dogs to the site which are potential sources of disease transmission.

Overview of Repi Landfill – Addis Ababa	
Landfill Operation	The major steps involved in site include spreading and leveling of wastes using Bulldozer followed by compaction using a compactor. The waste is not covered with soil or any other cover material which provides a breeding ground for pests and diseases.
Leachate Management	Repi dump site does not possess a leachate management system which prevents the toxic liquid waste leaking into the environment. As a result the leachate from the site is a potential source of surface and ground water pollution. In order to minimize the environmental and social impacts of the landfill, Addis Ababa city administration is on the process of closing 19 hectares of the site. As part of this effort the city planned to construct a leachate treatment facility for the remaining disposal site.
Landfill Gas Management	As its name suggests, Repi disposal site is a dump site where wastes are disposed in uncontrolled manner. Hence due to the day-to-day operational practices it is expected to release environmental pollutants in to the ambient environment. Hence, uncontrolled dispersal and migration of methane is the major cause (due to its flammability properties) of waste burning at Repi dump site.
Records	At Repi dump site records are maintained on daily basis to determine the volume and type of waste which is disposed off / number of trips for which vehicles made. Waste Recycling and Disposal Project (which is under City Manager of Addis Ababa city) planned to construct a Truck scale system.

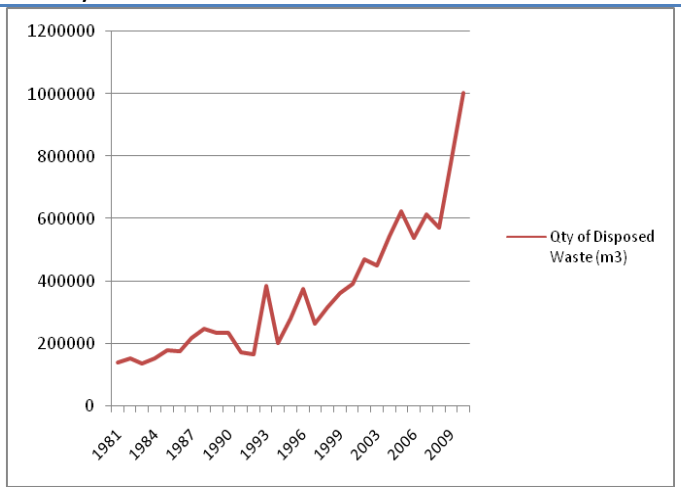

Figure 3. Quantity of solid waste disposed at Repi Dump Site (AACMA, 2010)

Mekele Sanitary Landfill Site

Mekele city has a sanitary landfill which is located at approximately 8km from the center of the city in western part of the city. The landfill has been in operation since 2008 and has an area of 21 hectare. It receives over 20,1606 tons of waste per annum and the waste is characterized as predominately non hazardous solid wastes. The general characteristics of Mekele sanitary landfill can be categorized as a valley/ ravine type where the waste is being placed in deep valley. The landfill is fenced by wire and masonry work (around its perimeter) which serves to restrict access to the waste by animals, screens the landfill, and delineates property lines. There is a gravel road which gives access to the landfill site.

Mekele sanitary landfill is designed and constructed in such a way that the waste is disposed in a controlled manner with an intention of minimizing its social and environmental impacts. The result is good control of landfill gas and leachate, and limited access of vectors (e.g., rodents, flies, etc.) to the wastes. The landfill has a gas venting system, collect and treat leachate, apply a daily soil cover on waste, and implementation plan for the closure and aftercare long after waste has ceased coming to the site. The following section describes the landfill's operation, methane gas and leachate management:

6. Since there is no truck scale at the landfill site, estimation of disposed solid waste quantities at the site is on the basis of multiplying the quantity of waste generated per person and multiply it by the total population. This is not at all reliable because of the change in density of the solid waste. Hence, it is difficult to estimate the quantity and composition of waste reaching disposal sites.

Overview of Mekele Landfill	
Landfill Operation	The major operational steps involved in Mekele sanitary landfill site include: First the waste which is delivered from the transfer station is being resorted into two parts namely biodegradable and non-biodegradable. The non-degradable wastes are stored at the site and the decomposable organic wastes are placed on the working face of the landfill site. The organic waste is then spread and leveled using dozers. Waste compaction using heavy steel-wheeled compactors. Compaction is an ongoing phenomenon that begins with compression and size reduction of particles by the compacting machinery and continues after the wastes are in place. The continuing compression is due to the weight of the wastes and that of the soil cover. The main purpose of compaction is to increase the capacity of the landfill. A minimum 15cm of soil cover material is applied at the end of each working day. Cover material is being applied at the site to minimize fire hazards, odors, blowing litter, and vector growth; discourage scavenging by animals; control venting of landfill gases; infiltration of precipitation; and provide an aesthetic appearance.
Leachate Management	Like most landfills Mekele sanitary landfill generates leachate from the waste that is being disposed on it. In order to prevent the impact of this toxic substance, the landfill is designed and constructed to prevent leachate from leaking into the environment. The landfill has the following leachate management system: a bottom line, a leachate collection system, a cover to prevent moisture from entering, and a good natural hydro-geological setting to protect the earth from the movement of wastes. The leachate collection system7 removes the leachate which will be stored and treated in a pond system by evaporation.
Landfill Gas Management	When MSW is disposed of in a landfill, naturally occurring microorganisms (bacteria) degrade the waste. The amount of water in and the temperature of the MSW control the rate of degradation. This process turns the organic portion of the waste into methane (a primary constituent of natural gas) and carbon dioxide in about equal proportions. The degradation process also generates very small quantities of organic compounds. Gases generated in the landfill can either be allowed to disperse and migrate beyond the confines of the fill without any effort being made to control them, or they can be collected. In order to avoid undesirable or hazardous conditions due to flammability of the accumulated landfill gas, venting units were built (using a wooden frame, a wire mesh, and crushed stone) at Mekele landfill site.
Records	Records are maintained on daily basis to determine the volume of waste / number of trips for which vehicles made. As the facility has been specifically designed for non hazardous solid wastes, only wastes that are generated from households, hotels, institutions, shops etc are accepted for disposal.

7 A typical leachate collection system may consist of (from bottom to top) a perforated leachate collection pipe placed in a drainage layer (gravel), a filter blanket, and a leachate collection layer.

Dire Dawa Sanitary Landfill

Dire Dawa sanitary landfill is located in Mude Hanano Kebele (sub-city), south-east of the city. It is about 7 km from the city center. The landfill possesses 13 hectares of land and commissioned in September 2007. Based on DDCASB agency (2011), until March 2011, the landfill accumulated / received over 9,174.98 tons of municipal solid waste. Access to the landfill site is controlled by a fence structure which is built around the perimeter of the site/ around the locations of easy access to equipment and by un-authorized individuals. The landfill employs an area method where the delivered waste is placed on flat land. It does not involve excavation of trenches; instead, a layer of waste is spread and compacted on the surface of the ground. Dire Dawa sanitary landfill, like that of Mekele, is designed and constructed in such a way that the waste is disposed in a controlled manner with an intention of minimizing its social and environmental impacts.

The landfill has a gas venting system, collect and treat leachate, apply a daily soil cover on waste, and implementation plan for the closure and aftercare long after waste has ceased coming to the site. The following section describes the landfill operation, landfill gas and leachate management at the site.

Overview of Dire Dawa Landfill	
Landfill Operation	The major operational steps involved in Dire Dawa sanitary landfill site is as follows: • First delivered waste is placed on the working face • The waste is then spread and leveled using a Dozers • Waste compaction using heavy steel-wheeled compactors. Compaction is an ongoing phenomenon that begins with compression and size reduction of particles by the compacting machinery and continues after the wastes are in place. The continuing compression is due to the weight of the wastes and that of the soil cover. The main purpose of compaction is to increase the capacity of the landfill. • A minimum 15cm of soil cover material is applied at the end of each working day.
Leachate Management	Dire Dawa sanitary landfill has a leachate management system to prevent the toxic liquid waste produced in the landfill-from leaking into the environment. The leachate control system has several components including: a bottom line, a leachate collection system, a cover to prevent moisture from entering, and a good natural hydro-geological setting to protect the earth from the movement of wastes. The leachate is then collected and treated in an evaporation pond.
Landfill Gas Management	Dire Dawa City has the plan to implement a gas flaring system where the landfill gas from collection pipes is burned. However, it currently has no landfill gas collection system setup.
Records	Records are maintained on daily basis to determine the volume of waste / number of trips for which vehicles made. The most important information in managing a solid waste system landfill facility is the quantity, type, and source of waste being collected for disposal. Truck scales are employed to determine the quantity of waste from each source. At Dire Dawa landfill site, only wastes from households, hotels, institutions, shops etc are accepted for disposal.

Overview of Waste disposal system in eight cities.

The studies made by Ethiopian Population and Housing Census Commission in 2008 and further studies conducted by Ministry of Work and Urban Development in 2009 gives following waste generation and collection figures of major towns:

Table 7. Estimation of Quantity of Waste disposed in 2010

(Year 2010)	HHW/c	Population	HHW/d	Coll.rate.	HHW/d/coll
Addis Ababa	0,380	2979100	1132058	70%	792441
Mekele	0,300	261200	78360	82%	64255
Nazret (Adama)	0,225	260600	58635	48%	28145
Dire Dawa	0,300	256800	77040	48%	36979
Bahir Dar	0,156	170300	26567	58%	15409
Awasa	0,230	200400	46092	44%	20280
Harer	0,300	108200	32460	45%	14607

The majority (more than 60%) of the wastes are from organic sources. There is currently no formal segregation or sorting done in any stage of the waste collection chain in all the municipalities. However, in most of the municipally landfill sites, there are number of scavengers collecting everything somewhat valuable. Although the amount of waste in dump sites is relatively low due to various factors, such as low collection rate and low income level, the situation might change rapidly due to fast economic growth of the country.

IV. LIST OF EXISTING OR PLANNED LANDFILL GAS CAPTURE AND/OR USE PROJECTS

Methane generation in landfills is a result of anaerobic decomposition of organic materials. Major factors affecting emission rates are:

1. Amount and quality of organic material deposited in landfills
2. Rate and distribution of anaerobic decomposition in different zones of the landfill
3. Moisture and oxygen levels
4. Landfill design and construction
5. Landfill methane collection and combustion

There are many other factors that influence the rates of methane production – factors that vary across societies and cultures. For example in developed and industrialized countries the waste stream tends to be drier and contains many materials that, in developing countries, are often recovered or informally scavenged before disposal from landfills (e.g., metals, plastics, wood, rags, etc.) Further, per capita rates of waste generation are much lower. Although the organic contents are high, the landfills in developed countries are rarely designed to capture and recirculate leachate properly. This can lead to too dry landfills which further will reduce the methane production.

Options for the disposition of LFG are:

1. Flaring
2. Industrial use directly piped short distances for power or heat generation
3. On-site power generation

4. Household use, after removal of CO2 and other impurities, pressurized and bottled
5. Heating and lighting of greenhouses near the site if applicable

A landfill gas system is used to collect and control gas emissions through a system of wells and prevents subsurface migration of gas off site. If not controlled, gas can build up pressure to an explosive level and/or cause methane as well as harmful air pollutants to be emitted into the atmosphere. Currently in Ethiopia all landfills are, as mentioned, open dump sites where such hazards are very rare. However, these should be taken in account when closing the site(s).

Sewage treatment and other biological sources

Biological sources of methane include sewage treatment, some agricultural production such as rice production, livestock operations, and biomass burning. While vegetation and agriculture can be major sources of methane, in developing countries such activities are often spread over large areas, at low levels of intensity, which poses serious obstacles to organized collection of methane. However, in the case of organized livestock operations, livestock and required infrastructure can be centralized and economical collection and use of methane may be possible.

Sewage

Sewage arises from both domestic and industrial sources. Treatment methods, and therefore methane emissions, vary considerably among various treatment plant designs. In developed countries, most municipal and industrial wastewater is collected and treated in an integrated sewage system. Treatment involves an aerobic degradation step for oxidation of dissolved and suspended organic matter, and emissions of methane from this step are generally low. Following aerobic digestion, settled aerobic treatment sludge, together with undigested solids from the

primary settlers and filters, are commonly reduced in volume by means of anaerobic digestion, which generates methane.

Landfill Gas In Ethiopia

There are currently no landfill gas collection system installed anywhere in the country. Even though energy production from municipal waste is commercially viable and has a positive impact on the environment by reducing health and safety hazards from methane gas releases, it is not a widely used practice yet. The Ethiopian Electric Power Light Authority has estimated that the total power production potential from LFG is estimated at 24MW.

The Addis Ababa landfill site will be partially closed by end of the year 2011. However, the current design of the landfill includes only methane ventilation but no collection or gas utilization. There are no approved plans for methane collection from existing landfill sites in other municipalities as well. Several unsuccessful attempts have been tried by private sector to utilize methane from Addis Ababa Repi landfill site. However, as per August 2011, the plan is just to close the Repi, ventilate gas out to atmosphere through safety wells without utilizing methane in any form.

While Repi would be gradually closed the new landfill site in Sendafa would be designed from the beginning to have an efficient methane collection and treatment system. Based on simulations (Poyry, 2010), the methane production will start within 3 – 4 years from the opening of the site. It is estimated that the site will receive 267,000 tn/y wastes in first year which will increase upto 691,000 tn/y within the lifetime of 20 years. The methane production is expected to reach, with 50% utilization rate, 17,820 Nm^3/hour after 22 years of operation i.e 2 years after the closure of the site. The landfill is expected to produce methane approximately 20 years after the closure.

The most likely scenario is that methane will be flared as there are no consumers in the vicinity of the site. Another option is to utilize methane for electricity production. It should be noted that landfill will not generate adequate gas flow, more than 1000 Nm^3/hour (required for 1MWe theoretically), until after 6 – 7 years of operation. Therefore, the landfill owner has not decided yet if gas should be utilized for any other than flaring, with possible carbon sales, purposes.

Table 8: Methane generation potential of Repi landfill

Year	Time(year)	LFG(m^3)	LFG(m^3), 50% to be harvested	Methane destroyed(t)	ER tCO_2e	Carbon credit(EURO)
2011	1	44664061	22332031	10049.41	211037.69	2110377
2012	2	41230125	20615063	9276.778	194812.34	1948123
2013	3	38060202	19030101	8563.546	179834.46	1798345
2014	4	35133995	17566998	7905.149	166008.13	1660081
2015	5	32432765	16216383	7297.372	153244.82	1532448
2016	6	29939216	14969608	6736.324	141462.79	1414628
2017	7	27637379	13818690	6218.41	130586.62	1305866
2018	8	25512517	12756258	5740.316	120546.64	1205466
2019	9	23551021	11775511	5298.98	111278.57	1112786
2020	10	21740333	10870166	4891.575	102723.07	1027231
2021	11	20068856	10034428	4515.493	94825.346	948253.5
2022	12	18525889	9262945	4168.325	87534.827	875348.3
2023	13	17101551	8550776	3847.849	80804.83	808048.3
2024	14	15786722	7893361	3552.012	74592.259	745922.6
2025	15	14572981	7286490	3278.921	68857.334	688573.3
2026	16	13452557	6726278	3026.825	63563.331	635633.3
2027	17	12418275	6209138	2794.112	58676.35	586763.5
2028	18	11463513	5731756	2579.29	54165.097	541651
2029	19	10582156	5291078	2380.985	50000.687	500006.9
2030	20	9768561	4884281	2197.926	46156.451	461564.5
Total		487,090,592	243,545,298	109,595	2,301,503	23,015,030

The KWWTP (Kaliti Wastewater Treatment Plant)

The Addis Ababa Water and Sewage Administration (AAWSA) together with NGO and private partners are interested in implementing cost-effective means of increasing the utilization of biogas at the Kaliti WWTP that can be accommodated within the relatively scalable plant site.

This is currently the only one project in Ethiopia under development which plans to collect methane from Addis Ababa Water and Sewage Authority's purification plant. The KWWTP (Kaliti Wastewater Treatment Plant) in the capital City of Addis Ababa, soon after its upgrade completes in 2012 expected to produce biogas containing approximately 60-70% methane and 30-40% CO2 as a byproduct of anaerobic digestion of secondary sludge treatment process.

Anaerobic digestion of sludge is one of the processes used to treat the wastewater received at the plant. As measured in 2010, the Kaliti WWTP intent to utilize from 2-4% of the produced biogas for plant electric generation (Standby Generator) to supply plant equipment during power shortage. However, the remaining of 96-98% biogas will be incinerated in a flare at an average rate of approximately 1,275 Nm3/h or 11,169,000.00 Nm3/year.

The existing Kaliti Wastewater Treatment Plant is a lagoon treatment system built in the late 1970's and commissioned in 1983. It has a design capacity of about 7,500 cubic meters per day or an equivalent population of 50,000 P.E. based on the Kaliti Sewerage Treatment Plant Maintenance and Operation Manual. The current facility has reached its capacity and must be upgraded to treat the increasing population and collection system expansion within the Kaliti catchment area. As outlined in the Update of the 2001 Sewage Master Plan, the intent of this report is to review alternate treatment process options to identify an appropriate process for the Kaliti site. The existing lagoons must remain in operation during the construction of the upgrades and existing infrastructure will be reused if appropriate. The actual Kaliti site is large but most of the space is occupied by the existing facultative and maturation ponds as well as the sludge drying lagoons and beds. This means that space is at a premium for upgrades to the wastewater treatment infrastructure.

One of the intents of the wastewater treatment plant upgrades is to minimize adverse effects from pathogenic components in the wastewater. As such, the effluent and sludge will be

treated to bring pathogenic levels down to an acceptable EPA limit. Following treatment, the effluent is planned to be reused for irrigation downstream of the plant site. Further information on the feasibility of the proposed irrigation project is provided in a separate report entitled Wastewater Treatment Plant Irrigation Feasibility Study. It is also the intention that the sludge treatment processes will produce sludge of sufficient quality that it can be reused as fertilizer.

There is also interest in recovering the biogas produced by sludge digestion and treating and refining the gas for a usable product. The City of Addis Ababa Water and Sewage Authority (AAWSA) is currently undertaking fundamental changes in the Municipal sewage waste management of the city. Accordingly, it is envisaged that the coverage of sewerage lines and networks will increase very significantly in line with the re-development and transformation of the city whereby the amount of influent to be processed at Kaliti wastewater treatment plant (KWWTP) will exceed the plant capacity. After the initial upgrading project complete in 2012, the plant will attain a capacity between, 100,000 to 250,000 m3/day of municipal wastewater influent.

The handling will be phased out. The effluent shall have to be treated biologically through (anaerobic treatment process) before it is discharged. The biological treatment process potentially can generate a significant quantity of methane gas which needs to be industrially processed through a biogas upgrading plant and prepared for commercialization (or utilization).

The forecast of the methane production capacity shows that the influent wastewater generated in the KWWTP have the potential to produce and displace the equivalent of over 21 thousand cubic meter of purified methane per day to natural gas quality, i.e. approximately 51% of the current imported LPG consumption per day.

The primary consideration in sewage treatment is public health, although the recovery of water

is also important consideration. Apart from direct agricultural applications or secondary production of low-grade nitrogen fertilizers, all treatments produce sludge which must then be disposed of. Options for treating this include composting, aerobic or anaerobic digestion, incineration, pyrolysis or direct landfilling. Composting and digestion yield a residual solid product that may be spread on agricultural land as fertilizer.

In Ethiopia, integrated systems are uncommon; the sewage collection system of Addis Ababa Water and Sewage Authority reaches only a fraction of households. Urban areas generally rely upon drain fields or septic tanks, which are more likely to produce methane as a result of anaerobic digestion. In rural areas it is more common for both liquid and sludge wastes to be applied to agricultural land. Composting sewage sludge or other municipal waste reduces its volume and produces an easily handled product. It requires a larger site area than other treatment options and may therefore be unsuitable for large urbanized areas. Composting is an aerobic process and produces little methane.

Anaerobic digestion of sewage has been promoted by SNV / Netherlands in Ethiopia. This methane may be flared or used as an energy source, to minimize emissions. The options available are similar to those for landfill gas but may be applied on a much smaller scale. Anaerobic digestion systems are very popular in India and in China, with several million single-household installations. The gas produced can be used for domestic lighting, cooking and heating, and by-products can be directly used as a fertilizer. Pyrolysis (gasification) may also be used to produce a low-grade fuel oil and a char product from either raw or treated sludge by heating to temperatures in the range 300-450°C. Although methane is produced, it can be used as fuel for the process. Currently there are no examples of sludge being processed by pyrolysis in Ethiopia.

City of Awassa - Example of growing municipality

Awasa (also spelled Awassa or Hawassa) is located in the Rift Valley region on the shores of Lake Awassa. It is the capital city of Southern Nationals, Nationalities, and Peoples Region (SNNPR) and it is about 270 Km south of Addis Ababa. It has an elevation of 1708 meters. The city hosts Hawassa University. Based on the recent (2007) census data from CSA of Ethiopia, the city has a population of 258,800 and has a population density of 1,646.26. The total household count is about 62 thousand with an average of size of 4.22 persons to a household. The 1995 census reported a total population of 69,169. The city has recorded a population growth of 400% in 12 years.

The city opened its first open dumpsite to collect and dispose solid and liquid waste in 1997. Since the rapid growth and urbanization of the town, the old open dump site became center of the city and as houses and schools started to be constructed around it; it started to have a negative health and environmental impact on the residents. The town closed down the solid waste disposal section of open dump site in 2010. The closure was done largely using locally available sand and installed concert tube to ventilate potential methane emission. The city plans to make the closed site a city park.

In 2010, the city opened a new landfill which is located about 3.2 Km from center of the city. The new landfill is constructed following professional landfill design with a plastic at the bottom and outlet for leachate management system. Even though, the landfill design and construction was done following some international guideline, the city now faces a major problem with the expansion of the city. As city grows and expands, houses are being constructed around the landfill and solid waste disposal is not done properly. Lack of proper disposal mechanism through with waste crushed and bulldozed has created a major problem and solid waste is not properly disposed in the landfill.

The old landfill in Awassa, closed and planned to be converted to city park

New landfill opened in 2010. Residential areas going up next to the landfill

Costs and potential benefits

Landfills

Total LFG collection system costs can vary widely as a function of several site-specific factors. If the landfill is deep, collection costs will tend to be higher because well depths and volumes of LFG generated per well are greater. Collection costs also increase with the number of wells installed.

As an example, it is estimated that the landfill gas collection and flaring systems for planned Sendafa Landfill would cost 14 Million ETB (Poyry 2010). Based on the current CDM market mechanisms the flaring could generate more than 35 Million ETB within first 7 year crediting period and 180 Million ETB in subsequent period. This is however unlikely as project would not start before 2012, which is one of the mandatory terms of current Kyoto Protocol CDM procedures. Further cost estimations are based on "USEPA report, "Turning a Liability into an Asset: A Landfill Gas-to-Energy Project Development Workbook", EPA 430-B-96-0004. All currencies are in USD.

Flaring costs are incorporated into the estimated costs of LFG collection systems because excess gas may need to be flared at any time, even if an energy recovery system is installed. Flare systems typically account for 5 to 15 percent of the capital cost of the entire collection system.

Table 9: Landfill gas generation estimation

Landfilled MSW (million metric tons)	**1**	**5**	**10**
Gas generation (m3/d)	29853	137448	242236
Collection system (CAPEX) '000	804	2673	4607
Collection system (OPEX/y) '000	121	207	296
LFG output (Btu/year)	100000	490000	850000

After the landfill gas has been collected, and before it can be used, it must be treated to remove any condensate that is not captured in the knockout tanks as well as particles and other impurities. Treatment requirements and costs depend on the end-use application. Minimal treatment is required for direct use of gas in boilers, while extensive treatment is necessary to remove CO_2 for pressurizing and bottling or use in vehicles.

The purified gas can then utilize in combustion gas engines, which would be feasible option if production capacity exceeds several MW. For smaller systems usually the modular microturbines are the most feasible option. As an example a Capstone CR65 microturbine, having output capacity of 130kW(e) and 230kW(h) would cost 450,000 USD installed. In Ethiopia there are currently no fixed tariffs (feed-in tariff) for electricity fed to the national grid, and there are no references from private power producers having power purchase agreement with Ethiopian Electric Power Corporation. Therefore, investments to electricity generation may not be feasible if electric power can not be used on-site (i.e. for leachate treatment).

V. LEGAL AND POLICY FRAMEWORKS FOR LANDFILL METHANE RECOVERY

Policy framework for Landfill Methane Recovery

The Environmental Policy of Ethiopia (EPE) is a policy that is sought to guide all environment related activities .it is taken from volume II of the Conservation Strategy of Ethiopia. It has an overall policy goal that reads as follows, to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through the sound management and use of natural, human made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. The EPE has specific policy objectives among which the following are directly relevant to our case. These read as follows,

- Identify and develop natural resources that are currently underutilized by finding new technologies, and/or intensifying existing uses which are not widely applied;
- Improve the environment of human settlements to satisfy the physical, social, economic, cultural and other needs of their inhabitants on a sustainable basis;
- Prevent the pollution of land, air and water in the most cost effective way so that the cost of effective preventive intervention would not exceed the benefits;

Landfill methane recovery is as previously defined, a technology that will use wastes that would have polluted the environment if not well managed. It is a way of managing wastes at the least. It goes much further that this and gets a useful thing from these wastes that must be disposed of and the acquisition of which has little or no cost.

Looking at it in view of the overall policy goal, it uses wastes that would have caused pollution if not well managed. Methane, that is, the gas that is extracted is very useful in aiding wood and dung for making fire. It makes waste a resource. Wastes are always there so this technology will never be short of resources. It therefore minimizes cost for everyone and very well manages resources. It also conserves wood and other fuels that are renewable natural resources. This process therefore improves and enhances the health and quality of life of all Ethiopians and promotes sustainable social and economic development through the sound management and use of natural and human made resources. This will manage the environment and as a whole meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

The specific policy objectives that are listed above are as stated the ones that are relevant to our case. Methane landfill recovery identifies a resource that can be both natural and human made. This is a technology not currently in use. This shows the fulfillment of specific objective indicated above. Using this waste will remove and therefore improves the environment. This satisfies a specific policy objective of the EPE that is stated above. It also works in the prevention of the pollution of “land, air and water” in the least of costs. This meets the specific policy objective of the EPA and government of Ethiopia.

Environmental Protection Authority of Ethiopia also has Key Guiding Principles that shape all subsequent policy, strategy and program formulations and their implementation . Some of the Key Guiding Principles directly refer to our case and it doesn’t contradict any. The directly relevant ones are stated as follows.

- Every person has the right to live in a healthy environment;
- The development use and management of renewable resources shall be based on sustainability;

- Appropriate and affordable technologies which use renewable and non-renewable resources efficiently shall be adopted, adapted, developed and disseminated;

Landfill Methane Recovery fulfills the key guiding principles in the following manner;

- By removing waste that would have polluted one's environment if not well gathered and disposed of a person will live in a healthy environment.
- Wastes are always there therefore there will not be an unsustainable resource.
- Landfill Methane recovery is a technology that uses a resource that is always there and the use of which will make the environment better. And therefore the use of this technology will be the first step towards adopting, adapting, developing and disseminating an appropriate technology.

Landfill Methane Recovery is also one of the areas promoted by the EPA for CDM development in the country.

Legal framework for EPA

Landfill methane recovery is technically regulated by the EPA and the EPA has a mandate to monitor and regulate the sector. Several proclamations provides EPA the legal mandate to do so. These are proclamation are 295/2002, 299/2002, 300/2002, 513/2007 and regulation number 159/2009. The first stated proclamation, that is, proclamation number 295/2002 is a proclamation that establishes organs for the Ethiopian Environmental Protection Authority. Proclamation number 299/2002 provides for the assessment of the impact on the environment. According to this proclamation Landfill Methane Recovery project has to be authorized by the Environmental Protection Authority or the relevant regional environmental agency to start implementation of any work. The Authority or the relevant environmental agency may ask for an environmental impact assessment report. This report may be done after consulting

communities that may be affected. An environmental impact assessment shall identify the likely adverse impacts of the project, the means of their prevention or containment. The environmental impact study report must be done by experts. It must include the following;

(a) the nature of the project, including the technology and the process to be used;

(b) the content and amount of pollutant that will be released during implementation as well as during operation;

(c) source and amount of energy required for operation

(d) information on likely trans-regional impacts;

(e)characteristics and duration of all the estimated direct or indirect, positive or negative impacts;

(f) measures proposed to eliminate, minimize or mitigate negative impacts;

(g) contingency plan in case of accident; and

(h) procedures of self auditing and monitoring during implementation and operation.

The Authority shall decide what elements should be included in an environmental impact study report and set guidelines. The project has to be implemented according to the time frame set during its authorization or otherwise the environmental impact study report will expire.
This proclamation has penal liability provisions. The presence of these provisions makes the presence of civil liability if found to be criminally liable possible due to the provisions of the extra-contractual liability.

Proclamation number 513/2007 is a law that manages solid waste. It is cited as Solid Waste Management Proclamation. This law guides as to how environmental protection agencies, regional states, urban administrations, physical or legal persons should act or interact concerning solid waste. This proclamation has civil and penal liability provisions.

VI. KEY STAKEHOLDERS IN THE SOLID WASTE DISPOSAL SECTOR AND LFG INDUSTRY

Landfills in Ethiopia are owned and managed by municipalities. Many of the municipalities have a unit that manages solid waste, landfill and recycling operations. Few municipalities add liquid waste and parks task to the unit. As Ethiopia has gone through decentralization during the past twenty years, municipalities have increasingly been responsible for managing solid waste operation and landfills. Even though, the decentralization has given municipalities more autonomy, it has also created a constraint as many have to raise their budget internally from taxes or other means. However, municipalities still get some of their budget from their regional administrations. Write more about decentralization and structure within cities

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VII. FINANCING OPTIONS

Landfill operation as well as power generation in Ethiopia is dominated by public sector or the government. Small scale power and energy generation from the private sector, particularly from the alternative sources, is encouraged. However, very little progress has been made. For the private sector, raising capital for renewable energy power projects is difficult and costly as lenders decline to finance such projects due to high level of perceived risks associated with them. There are several factors that make a renewable energy power project a risky business. Renewable energy technologies are relatively new and not yet mature in Ethiopia. Many local banks and lenders lack experience in assessing the associated risks. Moreover as technology improvements are quite fast, earlier technologies become obsolete so quickly entailing difficulty in competing with newer technologies. This potentially creates difficulty in competing with newer technologies. This potentially creates difficulty in projects to generate sufficient cash flow to ensure loan repayments. Difficulty of raising capital for renewable energy projects is further aggravated by their low capacity credits due to intermittent nature of resource availability which results in reduced cash flow due to reduce amount of power generation. This Has implication again on ability of loan repayment which lenders are very which concerned and want to ensure before giving out loans. These and several other factors such as difficulty in selling power at competitive price (high market risk) and high capital investment needed (higher transaction costs on the lenders side) make renewable energy projects less attractive to lenders without presence of appropriate government policies to facilitate and support.

One of the largest external funding mechanisms currently available to municipalities is the World Bank Urban Development Project. The World Bank Urban Development Project which has a component worth about US$145 million and grants eligible urban local governments to implement several local projects.

Activities that go under this project include:

- Sanitation (liquid waste) Sewer reticulation systems, wastewater treatment ponds, sludge ponds, community soak away pit and septic tanks, community latrines: dry pit, ventilated improved pit latrine, composting, drainage canals, vacuum trucks and vacuum handcarts, etc.
- Sanitation (solid waste management): Transfer stations, collection points, collection bins, landfills, biogas and composting plants, collection trucks, other collection equipment and landfill site equipment including compaction vehicles, etc.
- Integrated infrastructure and land services (for housing, SME, industrial zones)
- Land development, servicing land with utilities (water supply, electricity, telecommunications and survey), roads and drains solid & liquid waste collection & disposal, etc
- Urban drainage: Drainage and flood control systems, etc.
- Built facilities: Urban markets with associated services (water supply, drainage, access roads, etc), development o f production and market centers for small businesses, slaughter houses with by-products processing facilities, etc.

Through this funding, US$79.8 million will be divided to 17 proportionally according to the population shares after a lump sum allocation o f US$10 million Addis Ababa and US$9.2 million Dire Dawa are given.

VIII. DOMESTIC COUNTRY STRATEGY

Ethiopia has a decentralized government structure and municipalities and cities have autonomous authority to design, implement and oversee solid waste collection as well as landfill management. However, at the federal level there are two government institutions that have authority to provide the framework for assistance as well as facilitate and coordination donor assistance.

The Ministry of Works and Urban Development (MoWUD) was established in October 2005 to implement the governments' Urban Development Policy. It has the mandate to assist municipalities in their efforts of managing solid waste as well as landfills. The MoWUD was established after the government approved a national Urban Development Policy which was part of the governments poverty eradication strategy referred then as the Plan for Accelerated and Sustained Development Programme (ran from 2005/6 t0 2009/10). The main objective of the Urban Development Policy was to assist municipalities in providing efficient and effective public services to residents, complement and facilitate rural development etc. targeting to build accelerated economic opportunities that create jobs.

Under the current decentralized system, Addis Ababa and Dire Dawa are federal chartered cities with the status of regions and thus the City Council of each does report directly to the federal government or the Prime Minister's office. Under the current structure, municipalities have the authority and mandate to raise revenues, deliver services and be accountable to their own councils. The city councils are in turn accountable to the regional government. In addition to the city administrations office, most regions also have the Bureaus of Works and Urban Development which are responsible for urban management and development issues within the regional government. Regional states (11 in number including the cities of Addis Ababa and Dire

Dawa) also have regional Urban Planning Institutes (RUPIs) which support Bureaus of Works and Urban Development. Several of the World Bank Urban Local Government Development Projects are implemented in the municipalities with support from Bureaus of Works and Urban Development as well as Bureaus of Finance and Economic Development.

While the Ministry of Works and Urban Development has the institutional mandate in facilitating in facilitating infrastructural development in municipalities, the Environmental Protection Authority has a corollary duty on setting the general vision on greenhouse gas abatement. The Authority is re-established back in 2002 as an autonomous entity accountable to the Prime Minister's Office. The main goal of the Authority is to see that environmental policies and laws are implemented at all administrative levels and across all sectors. It has hence created nodal bodies with in all the regional states and environmental units across major sectors. The role of ensuring that environmental standards are aligned with in the functions of sectoral bodies is left to environmental units established/ or to be established under each sectoral agency. These units are currently reshaped to assume wider functions and are hence renamed "CRGE Units" reflecting the desired form of development – a climate resilient green economy. So their basic mandate will include considering climate adaptation and mitigation in the day to day activities of the sector institution. It means that the CRGE Unit within the MoWUD will see to it that land fill gas will be reduced over the years so that the potent greenhouse gas (methane) will not escape into the atmosphere. Reduction of greenhouse gasses is not as such a legally binding obligation on Ethiopia. But as the 1996 Environmental Policy of the country puts it, the country wishes to place a strong moral point by reduce the emission of greenhouse gasses despite the relatively low level of total emissions compared to global standards.

Apart from this, the authority has been instrumental in adopting the Solid Waste Management law (Proclamation No. 513/ 2007) which further empowers urban administrations to lead their

waste management functions according to predesigned plans. At present cities are on the way to develop capital investment plans to undertake a wholistic and integrated solid waste management programme. This is obviously going to demand a huge capacity in human resources as well as finance.

The Authority has recently developed a broader climate vision referred to as the Climate Resilient Green Economy Strategy. This national strategy is undergoing national consultation across regions and sectors. The development of this strategy has identified one sector, namely green cities and buildings as a big opportunity for abatement in Ethiopia despite the country's low level of greenhouse gas emissions compared to global standards. Gas capture and flaring from both landfills and liquid waste is expected to be a huge potential (according to preliminary estimates this abatement potential is in the range of 0.9 Million Tonnes of Carbon dioxide equivalent every year by 2030 for each case).

XI. CONCLUSIONS AND OBSERVATIONS

Ethiopia is currently going through rapid economic development as well as political transition. The economic development, in addition to high rate of urbanization and population growth, has put a constraint on municipalities in delivering essential services. At the same time, traditional system of service delivery, including solid waste collection, is being transferred to private sector or handed down to lower level of government apparatus for management. Municipalities that have done so have shown improvement in solid waste collection and management. Lack of manpower and technical skill remain to be the most important bottleneck in addressing solid waste collection and landfill management. Some of the other common challenges observed in municipalities are

- Absence of waste segregation at the source
- Lack of No standard solid waste transfer station
- Lack of collection from all solid waste generators
- Poor landfill/dump site management

In order to improve solid waste collection and landfill usage, municipalities need to address these issues. While the current decentralized system allows local administrations to be more accountable to citizens and be informed about the needs of the communities, local administrations are also poorly equipped to establish, manage and/or monitor solid waste collection and landfills. There are currently few national level initiatives established to provide national level guidance and assistance to municipalities. National level coordination will continue to be essential in capacity building as well. At the national level, policies and programs also need to be devised and encouraged at the local to promote recycling and other programs

such as composting. Traditional landfill construction and operation may not necessarily address the needs of the country as landfill construction and management requires large scale investment. While such programs might work in Addis Ababa, all the other municipalities do not have the financial and technical resources to implement such a program. Therefore, in order to address the challenges of solid waste management, municipalities need to integrated innovative solutions that look at improving primary and secondary collection as well as recycling.

XII. REFERENCES AND SOURCES

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